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REPORT ON INTERSTATE AIR POLLUTION IN THE SHOREHAM, VERMONT - TICONDEROGA, NEW YORK, AREA

Public Health Service
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U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service
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INTRODUCTION

Pursuant to a request from Governor Philip H. Hoff of the State of Vermont, the Secretary of Health, Education, and Welfare, under provisions of Section 5 of the Clean Air Act, Public Law 88-206 (42 U.S.C. 1857d), called a conference to be held November 30, 1965, in Burlington, Vermont, regarding an interstate air pollution problem in which it is alleged that air pollution emanating from an International Paper Company pulp plant in Ticonderoga, New York, endangers the health or welfare of persons in the Shoreham, Vermont area (Figure 1).

The International Paper Company pulp mill is located on Montcalm Street in the east-central section of Ticonderoga, Essex County, New York, approximately two miles west of the Vermont-New York boundary, which lies in Lake Champlain. The lake is approximately one-quarter to five-eighths mile wide in this area, and the Vermont shore is about 2-1/4 miles from the pulp mill. Operations of the mill consist primarily of the production of bleached hardwood pulp, and a smaller quantity of unbleached softwood pulp, by the kraft pulping process. The population of Ticonderoga, New York, according to the 1960 census, was 3,568 persons.

The town of Shoreham, Addison County, Vermont, located approximately 6 miles east-northeast of the pulp mill, is located at the junction of State highways 74 and 22A. Population of Shoreham in 1960 was 786 and the population of Addison County was 20,076.

This report summarizes the activities undertaken, subsequent to receipt of the Vermont request, by the Abatement Branch, Division of Air Pollution, Public Health Service, Department of Health, Education, and Welfare, along the following lines: (1) inspection of the pulp mill operated by the International Paper Company in Ticonderoga, New York, (2) review of available topographical and meteorological information, and (3) calculation of emissions, transport and diffusion of odorous materials from the mill site.

ODOR EMISSIONS FROM THE KRAFT PULPING PROCESS

The kraft pulping process consists, essentially, of chemical separation of cellulose fibers from the lignin and other non-cellulose portions of wood. The fiber, or pulp, is used to manufacture paper. The non-fiber portion of the wood is burned to produce process heat, and the chemicals are recovered and re-used.

In response to an inquiry from the Secretary of Health, Education, and Welfare, the International Paper Company advised that hydrogen sulfide, methyl mercaptan, dimethyl sulfide, and dimethyl disulfide are emitted from the company's Ticonderoga pulp mill, and that sulfur dioxide is emitted from the steam boiler plant; but the Company did not furnish data on quantities of these substances which are emitted.

The International Paper Company permitted representatives of the Abatement Branch to observe processing equipment and air pollution control devices at its Ticonderoga pulp mill on November 16, 1965. This voluntary cooperation is gratefully acknowledged. During this visit, certain information on plant operation, production, and equipment capacities was provided by Company personnel. This information, along with emission factors based on experience at other kraft pulping mills, has been used to calculate emission rates for some odorous gases.

The Ticonderoga plant is a conventional kraft mill employing about 1,000 persons and producing 200 tons of pulp per day on an air-dried, unbleached basis. Wood furnish presently is about 80 percent hardwood, consisting of approximately equal amounts of birch, maple , and beech, with small amounts of oak; the 20 percent softwood is white pine. The Company reportedly plans to process hardwoods only in the near future. Figure 2 is a simplified flow sheet of the kraft pulping process typical of that used at the International Paper Company's mill at Ticonderoga.

Although there are many sources of odors in kraft pulping mills, calculations to quantitate emissions are limited in this report to the sources identified by the International Paper Company. These are believed to be the principal sources or points of generation of odors from the mill. Other sources within the plant ordinarily are associated with these major sources in the handling of process materials or wastes.

Quantities of specific odorous gases have been calculated on a conservative basis. When information on a specific source was not available, no emission was calculated. When a choice of emission factors was available, a conservative value was chosen. Collection efficiencies reported by the Company for existing air pollution control devices have been used in the calculations.

Calculations were based on the reported production rate of 200 tons of pulp per day and continuous 24-hour per day production with non-fluctuating emission rates; except that digester emissions were based on the 10-minutes at the end of each batch when pulp is discharged to the blow tank, even though there are brief periods during each cook when gases are released from digesters. Since there are 25 digester charges per day, the 10-minute emission occurs at an average rate of about once per hour.

Fluctuations in production rates cause fluctuations in air pollutant emission which, from some sources, are greater than proportional to the increase in production. The efficiency of air pollution control devices, if not designed for overload, will be less when overloaded than when operating at design capacity.

DIGESTION

Wood chips are cooked under pressure in batch digesters in a solution of sodium hydroxide and sodium sulfide. During a cooking period, non-condensible gases are relieved periodically from the digesters. At the end of a cooking cycle, a valve at the bottom of a digester is suddenly opened and digester contents are forced into a receiver called a blow tank. In this tank, the pulp and liquor separate from the steam and gases, the latter passing through a surface condenser for recovery of heat and condensates. Uncondensed gases, which in the past were released to the atmosphere, are now passed through a three-stage chlorination scrubber which was installed in September 1965.

The three-stage scrubber consists of (1) a unit filled with perforated wooden baffles, through which gases pass concurrently to a deluge of chlorine solution from the bleaching process; and (2) a two-state scrubber containing duplicate sections filled with plastic balls to distribute the flow of falling chlorine water and facilitate intimate contact with the rising gases, which are discharged to the atmosphere through a stack about 60 feet above ground level. Condensed gases and chlorine water from the scrubbers are discharged to sewer.

During one digester blow, at the time of the Abatement Branch's tour of the plant on November 16, 1965, the induced-draft fan in the discharge stack was not operating and digester blow gases escaped to the atmosphere through a pressure-relief valve on the ducting that leads to the surface condenser. When the fan was activated, prior to the next digester blow, it was observed that only minor amounts of steam and associated odorous gases escaped directly to the atmosphere from the pressure-relief valve. This escaping gas represented a small portion of the total blow gas and persisted for only a short time at the beginning of a blow.

It is estimated by the International Paper Company that these scrubbers have an efficiency of 80 percent in the removal of noncondensible gases.

Based on the production rate and control efficiency reported by the Company, it was calculated that daily emissions of odorous gases from digester blows are as follows: 18 pounds of hydrogen sulfide, 100 pounds of methyl mercaptan and 56 pounds of dimethyl sulfide. Addition emissions, not included in these estimates, will result from leaks in the system and gases which escape through the pressure-relief vent in the blow-tank piping.

MULTIPLE-EFFECT EVAPORATION

Chemicals are recovered from the spent cooking liquor for re-use. The spent liquor, called black liquor, is concentrated from about 18 to 50 percent solids in multiple-effect evaporators which are indirectly heated with steam. Vapor from the last of five effects is condensed in a surface condenser. Condensates from the evaporators and condenser are combined and flow to a hot-water storage tank where they are mixed with other mill hot waters for general plant use.

Uncondensed gases are removed by means of a steam ejector and discharged to the atmosphere. Although the quantity of uncondensed gases from such evaporators is relatively small, concentrations of organic gases and odorous materials are high. Calculated emissions are 240 and 8 pounds per day, respectively, of hydrogen sulfide and methyl mercaptan.

DIRECT-CONTACT EVAPORATOR AND RECOVERY FURNACE

The final stage of concentration of black liquor, from 50 to about 67 percent solids, is by direct-contact evaporation. This operation represents a sig-

nificant and variable source of emissions. In the Ticonderoga mill, evaporation is accomplished in a venturi evaporator-scrubber through which all of the hot flue gases from the recovery furnace pass. In this venturi scrubber the black liquor recovers heat and collects particulate chemicals from the furnace flue gas. Under some conditions such a scrubber may remove hydrogen sulfide from the furnace flue gas; under other conditions hydrogen sulfide may be released from the black liquor to the gas stream.

Strong black liquor, after direct contact evaporation, is forced through spray nozzles into a recovery furnace. The dissolved lignin and other organic materials are burned to produce heat, and the inorganic chemicals fall to the floor of the furnace in a molten state. These molten chemicals, called smelt, are withdrawn from the furnace to a tank where they are quenched and recovered for re-use.

The recovery furnace, as rated by the manufacturer, is capable of burning the liquor from 180 tons per day of unbleached pulp. Mill personnel report black liquor feed to the furnace at 38,500 pounds per hour. Flow is measured and regulated by nozzle pressure, which can be maintained at a steady level because of adequate liquor storage facilities.

The recovery furnace is equipped with an induced draft fan and the venturi scrubber in which black liquor is concentrated before firing in the furnace. Rated capacity of the fan is 67,500 cubic feet per minute and reportedly it is operated at 80 percent of power. Using the highest reported value for stack gas temperature and a conservative value for hydrogen sulfide concentration in the stack effluent, it is calculated that 1800 pounds of hydrogen sulfide per day are emitted from the furnace. Insufficient information is available to permit calculation of emission rates from the furnace for other odorous sulfur gases.

The presence of 2 or 3 percent excess oxygen in the recovery furnace flue gases, after adequate mixing in the oxidation section of the furnace, materially reduces hydrogen sulfide concentrations in the furnace effluent; but it does not necessarily control subsequent emissions of hydrogen sulfide from black liquor in direct-contact evaporation. Operation of a furnace beyond its design capacity decreases the capability for maintaining excess oxygen in the effluent and increases the hazard of explosion. An oxygen analyzer-recorder has been installed to monitor the oxygen content of the gases leaving the recovery furnace at the Ticonderoga mill. This instrument indicated zero excess oxygen during the Abatement Branch's plant tour.

SMELT TANK, CAUSTICIZING PLANT, AND LIME KILN

The smelt tank and lime kiln are potential sources of odorous sulfur gases, but insufficient information is available to permit calculation of emissions.

Quenching of smelt generates steam and particulates. It is planned to install a scrubber on the smelt tank at the Ticonderoga mill by June 1, 1967.

STEAM BOILER PLANT

Although not a part of the kraft process per se, the Ticonderoga mill has a coal-fired steam boiler plant with three vibrating-grate furnaces which consume 120 tons of coal per day. Sulfur content of the fuel is reported to be 2 to 3 percent. Using the average value of 2.5 percent sulfur, it is calculated that 12,000 pounds of sulfur dioxide are emitted daily by the boiler plant.

SUMMARY OF CALCULATED EMISSIONS FROM PULP MILL

The calculated combined emission of hydrogen sulfide from the digester scrubbers, evaporators and recovery furnace is 2,050 pounds per day; and the computed emission of methyl mercaptan and dimethyl sulfide from the digester scrubbers and evaporators are 108 and 56 pounds per day, respectively.

It should be emphasized that these are conservative values, and they may be low by a factor of two or three. For example, if the recovery furnace effluent should contain only 15 parts per million of methyl mercaptan, the quantity of this malodorous compound emitted by the furnace would be 135 pounds per day giving a total more than twice the calculated emission for the entire plant. Similarly, depending on assumptions, emission of hydrogen sulfide from the recovery stack reasonably may be estimated up to 4500 pounds per day, or two and one-quarter times the calculated value.

Dearth of information has prevented development of a comprehensive inventory of odorous materials emitted by the mill. Certain sources have not been included because information is lacking, and no emission estimate was made of such odorous gases as dimethyl disulfide and methyl mercaptan, which are emitted from some pulping operations.

OTHER ODOR SOURCES

Observation and inquiry have revealed no significant air pollution sources in the Shoreham, Vermont-Ticonderoga, New York area, other than the International Paper Company pulp mill in Ticonderoga, which produces the distinctive "rotten egg" and "rotten cabbage" odors characteristic of kraft pulp mills. Essex County, New York, and Addison County, Vermont, have relatively little manufacturing industry. Of the some 9,600 persons employed in these counties in 1962, about 6,000 were engaged in non-manufacturing pursuits such as agriculture, mining, construction, and commerce.

Of the some 15,000 dwelling units in the two counties in 1960, almost 12,000 were heated with oil. Oil used for domestic purposes ordinarily is relatively low in sulfur content. Fewer than 10 percent of the dwelling units were heated with coal. Domestic heating is a diffuse source of sulfur gases in the Ticonderoga-Shoreham area, and has little effect upon the interstate air quality.

DISCUSSION OF CONTROL TECHNOLOGY

DIRECT-CONTACT EVAPORATOR

In this type of evaporator, strong black liquor is contacted directly with the hot flue gases from the recovery furnace. These gases contain nitrogen, some oxygen, water vapor and about 10 to 12 percent carbon dioxide. They also contain minor amounts of sulfur dioxide and may contain odorous sulfides, including hydrogen sulfide. The black liquor in contact with these gases contains sodium sulfide and other alkaline sodium salts as well as dissolved materials from wood.

The equilibrium partial pressure of hydrogen sulfide above the black liquor is given by the relationship,

$$P_{H_2S} = (K) \ (C_{Na_2S}) \ (C_{H^+}),$$

in which P_{H_2S} is the equilibrium pressure of hydrogen sulfide above a solution in which the concentration of sodium sulfide and hydrogen ion are C_{Na_2S} and C_{H^+}, respectively. The term K is a proportionality constant.

When carbon dioxide contacts the alkaline black liquor, the gas is absorbed and the pH of the liquor decreases (C_{H^+} increases). As a result, P_{H_2S} increases and hydrogen sulfide tends to be released from the black liquor.

As shown by the equilibrium equation, there are two ways in which this release of hydrogen sulfide during direct-contact evaporation can be reduced: (1) Maintaining a high pH level (low value of C_{H^+}) in the black liquor. Since the liquor is in contact with the flue gas stream which contains a large proportion of carbon dioxide, this usually is not practicable. (2) Reducing the concentration of sodium sulfide (C_{Na_2S}) to zero or as near zero as is possible. This can be achieved by oxidizing the sodium sulfide in the black liquor, thus converting it to sodium thiosulfate. When the complete conversion of sodium sulfide is achieved, C_{Na_2S} is zero and P_{H_2S} also is zero. If the liquor is thoroughly oxidized before it enters the venturi evaporator, the release of hydrogen sulfide from this source may be greatly reduced.

The black liquor preferably should be oxidized before it enters the multiple-effect evaporators, and it certainly must be oxidized before it enters the venturi evaporator if hydrogen sulfide emissions from this source are to be effectively controlled.

RECOVERY FURNACE

To prevent release of odorous sulfides from a recovery furnace, four conditions of operation must be satisfied:

(1) Adequate excess oxygen for complete combustion.

(2) Thorough mixing of oxygen and combustible materials.

(3) Vertical velocities in the furnace low enough to permit adequate time for mixing and reaction in the combustion zone.

(4) Temperature in the combustion zone of the furnace high enough to cause rapid reaction between any sulfide gases and oxygen

According to information provided by International Paper Company personnel, the furnace was designed to burn the liquor from 180 tons per day of pulp. The mill presently is producing 200 tons per day, so the furnace is operating at about 111 percent of its design rating. Operating data from similar recovery furnaces indicate that the unit should be capable with good operation of burning this quantity of black liquor without emission of hydrogen sulfide.

NONCONDENSIBLE GASES FROM DIGESTER AND MULTIPLE-EFFECT EVAPORATOR

A three-stage scrubber system was installed at the mill in September 1965 to treat gases from digesters. It is suggested that engineering evaluation be undertaken to determine the feasibility of the following changes and additions:

(1) Ducting of the noncondensible gases from the multiple-effect evaporators to the gas entry point of the first stage of the scrubber.

(2) Utilization of caustic liquor in the final scrubbing stage. Caustic scrubbing would remove excessive chlorine gas and any residual acidic gases from the exhaust gas stream, but mixing of caustic and acid chlorine liquors in the scrubber should be avoided to avert a foaming problem.

(3) Making every possible effort to prevent the escape of digester gases to atmosphere before treatment in the scrubbing system.

(4) Routine testing to insure that there is sufficent residual oxidant in the chlorination liquor entering the scrubber. Such tests, combined with analyses of influent and effluent gases from the scrubber system, would assist in establishing best operating conditions and in monitoring effectiveness of the system.

PERSONNEL RESPONSIBILITIES FOR ODOR ABATEMENT

Installation of odor abatement equipment is only part of the solution to tne problem of kraft mill odors. Operating personnel must be concerned with maintaining the best operation of the equipment and with good housekeeping to minimize odor release. Consideration might be given to designating one person, directly responsible to management, as pollution control officer for the mill. Duties could include location of odorous emissions, regular testing to insure that abatement equipment is operating well, recommendations for additional control methods, and submission of periodic reports to the mill manager on pollution releases, equipment operation and suggestions for improvement.

Had a pollution control officer been assigned, it is likely he would have discovered and corrected the two malfunctions (that is, the fan in scrubber exhaust stack not operating, and the oxygen analyzer inoperative or no excess oxygen in recovery furnace flue gases) which were observed during the Abatement Branch's tour, as well as other factors contributing to the odor problem.

METEOROLOGY

EFFECTS OF TERRAIN ON WIND MOVEMENT AND TEMPERATURE INVERSION CONDITIONS

The Ticonderoga-Shoreham area lies in the "prevailing westerlies," the belt of generally eastward air movement which encircles the globe in middle latitudes. Embedded in this circulation are extensive masses of air originating in higher or lower latitudes and interacting to produce low-pressure storm systems. Relative to most other sections of the country, a large number of such storms pass over or near the area.

A procession of contrasting air masses and the relatively frequent passage of "lows" bring about, on the average, a twice-weekly alteration from fair to cloudy or stormy conditions, often attended by abrupt changes in temperature, moisture, sunshine, wind direction and speed. There is no regular or persistent rhythm to this sequence, and it is interrupted by periods during which the weather patterns continue the same for several days or, infrequently, for several weeks. The weather is cited for variety rather than monotony. Over the region in which Ticonderoga is located, the prevailing upper wind is from the northwest in winter, and from the southwest in the warmer part of the year. Because of rugged topography, however, local winds parallel valleys. In particular, winds from a general northerly or southerly direction are channeled through the long valley of the Hudson River and Lake Champlain, but winds from easterly and westerly directions are blocked by the Adirondacks to the West and the Green Mountains to the East. The valley in which Lake George is located also provides a channel for the wind and accounts for much of the southwesterly flow experienced in the Ticonderoga area which transports air pollution from Ticonderoga across Lake Champlain into Vermont.

Air, with any pollutants that it contains, moves freely across the Lake. Air trajectories from Ticonderoga have a tendency to turn northward or southward, following the Lake, or to follow the line connecting Lake George, Cedar Swamp in the Shoreham area, and Fair River Swamp, near Bridport, Vermont. The low hills of the Shoreham-Bridport areas do not present a significant obstacle to the movement of air pollution.

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With light winds, very complicated trajectory patterns develop in the vicinity of Ticonderoga because of the nearby mountains. At night, with radiation or surface heat, air draining down the mountains produces local winds and a pool of colder air in the valley, thereby enhancing nocturnal temperature inversion effects. Light winds are generally associated with the accumulation of any air pollution, and the inversion conditions are associated with poor diffusion conditions.

To some extent, the water of Lake Champlain, cooled in the winter, acts as a "heat sink" to retard the onset of spring. The cold water increases atmospheric stability conditions and inhibits vertical dispersion of air pollution. With light winds and water colder than the air, a plume remains intact as it crosses the Lake. Conversely, summer warmth is stored in the Lake water to lengthen that season and delay the occurrence of frost. This phenomenon accounts, in part, for the cultivation of apple orchards bordering the Lake. Water that is warmer than the air results in some turbulence to aid in dispersing a plume, although at times the layer of air warmed by the water will be relatively shallow and a plume aloft will not be significantly affected.

WIND DIRECTION AND SPEED

Records of wind direction and speed in the Ticonderoga area are not available from Weather Bureau sources. The nearest stations with wind records are Albany, New York, and Burlington, Vermont. The wind roses for these stations clearly show the great effect of topography in eastern New York and western Vermont (Figure 3). The Burlington wind rose shows the strong effect of the North-South air flow along Lake Champlain, and the Albany wind rose shows the effect of the air flow north and south along the Hudson River Valley and from the west-northwest down the Mohawk River Valley. The frequency of north and south winds in the Ticonderoga-Shoreham area would be about the same as at Burlington. Frequencies of other directions can be estimated only from the configuration of the topography. At Burlington, the annual frequency of winds from the south-southwest and southwest is 18%; however, in the months June through September the average frequency is 22%. The frequency of south-southwest and southwest winds that would transport air pollution from Ticonderoga to the Shoreham area would be considerably greater, because of the orientation of Lake George and because some of the prevailing westerlies can penetrate the region around the southern Adirondacks. Therefore, there is no doubt that the frequency of south-southwest and southwest winds in the Ticonderoga region in the warm months is greater than 25%, and the frequency could be as great as 30%. Winds from a northwesterly direction occur somewhat less frequently than at

Burlington, and other directions occur with essentially the same frequency.

At Burlington, winds are from the south-southwest through north-northwest more than 40% of the time. This frequency, or greater, will occur in the Ticonderoga area, and is indicative of the proportion of time that interstate transport of pollution can occur. The average wind speed is about 8 mph.

CALMS

Calms occur with an annual frequency of about 10%. The frequency of light winds, ranging from zero to three miles per hour, is between 20 and 25%.

An offensive smell is more noticeable and persistent under calm or light wind conditions. Smells are stronger in summer after sunset. With the cooling of the ground, air becomes stable; and with little or no wind, odors are mixed only slowly with the air and they remain concentrated. Convection currents cease, and odors originating near the ground remain there. In the transition period near evening when surface temperature inversions are forming, an odorous stack plume aloft can be brought downward as the result of some mixing due to ground roughness, or other causes, so that part of it becomes trapped in the stable surface layer. There it will remain and dilute slowly.

After sunset, the air cools rapidly, so humidity increases. The sense of smell is more acute when air is moist and odors are, therefore, more noticeable in the evening.

A combination of calms or light winds and rainy or damp weather, as would be expected, also is associated with intense odor conditions.

INVERSE CONDITIONS

Nighttime temperature inversions have important effects on air pollution in the Ticonderoga area. A U. S. Weather Bureau meteorologist has reported inversion frequencies for this part of the United States as follows:

Percentage frequency of inversions

	8 A.M.	7 P.M.	Total Time
Winter	47	43	27
Spring	63	45	25
Summer	75	52	31
Fall	60	66	37
Annual			30

In Ticonderoga, with mountains nearby, these figures are lower than actual, for topographically protected areas have more frequent inversions than regions of the country generally.

No information is available on the depth of the nighttime inversions, but cold air drainage down the mountains on three sides of Ticonderoga insures a relatively deep inversion. Local air pollution and stack plumes are trapped within the inversion layer. Solar heating of the ground surface and mountain sides in the morning causes overturning of the air and fumigations which bring stack plumes to the ground and add to the air pollution problem.

TRANSPORT AND DIFFUSION OF ODOROUS GASES

Using generally accepted meteorological dispersion methods and the calculated emissions of odorous gases from the International Paper Company pulp mill, average downwind concentrations of these gases for periods of 3 to 15 minutes have been computed. The calculations show that under stable conditions and low wind speed significant concentrations occur at relatively great distances from the source. For example, the conservative emission of hydrogen sulfide calculated for the mill produces an average concentration of 0.1 parts per million (100 times the minimum perceptible level) at a distance 6.2 miles downwind with stable conditions and wind speed of 2 1/2 miles per hour (Figure 4). Under stable conditions and with a wind speed of 5 miles per hour, an average of 0.1 parts per million occurs 1.9 miles downwind, and 10 parts per billion (10 times the odor threshold) occurs 33 miles downwind (Figure 5).

Under neutral conditions, at a wind speed of 5 miles per hour, an average concentration of 10 parts per billion will occur 7.5 miles downwind while 0.1 parts per million will occur 1.2 miles from the source (Figure 6).

With unstable conditions, rapid mixing reduces the distances at which specific concentrations will be found. Five-mile-per-hour winds with unstable conditions yield an average concentration of 0.1 parts per million less than 0.3 mile and 10 parts per billion about 0.5 mile downwind (Figure 7)..

Methyl mercaptan has a very characteristic odor and persist in the air for long periods of time. Even with the very small quantity calculated for emission from the Ticonderoga mill, the odor can be detected at substantial distances under certain meteorological conditions.

Under stable conditions and with a wind speed of 2.5 miles per hour 0.1 parts per million (100 times the minimum perceptible level) will occur 2.2 miles downwind. Should the meteorologic condition persist, the concentrations would be 10 parts per billion, or 10 times the odor threshold, 17 miles downwind (Figure 8).

Under stable conditions with a wind speed of 5 miles per hour an average concentration of 0.1 parts per million, or 100 times the odor threshold, will occur 1.2 miles downwind and 10 parts per billion will occur 9 miles downwind (Figure 9).

With a wind speed of 5 miles per hour and under neutral conditions, 10 parts per billion will occur downwind at a distance of 2.5 miles and the odor threshold will occur downwind at a distance of 12 miles (Figure 10). Under unstable conditions at the same wind speed these concentrations will occur 0.4 and 0.8 miles downwind (Figure 11).

For periods of less than 3 to 15 minutes, higher concentrations occur. For example, under unstable conditions, a stack plume loops to the ground and short-time concentrations more than 20 times greater than the average occur. Under other meteorologic conditions, fluctuations in concentrations occur, giving short-time concentrations greater than the average, but the peak-to-mean ratios are less than for unstable conditions.

In this discussion the concentrations of odorous gases have been considered individually. Different odorous gases from the pulp mill are emitted concurrently, however, and appear in the receptor areas together. Selective oxidation or absorption may alter their relative concentrations, but the combined effects of two or more odorous gases may be additive or synergistic.

EFFECTS OF ODORS

Of all man's senses, least is known about olfaction. The nose is so sensitive that no scientific instrument approaches it in sensitivity or versatility as an odor meter. It can respond to thousands of distinct odor stimuli and can detect odors in extremely dilute gaseous concentrations.

Response to an odor, however, is almost entirely subjective. What is pleasant or fragrant to one person may be unpleasant or malodorous to another. Kraft pulp mill odors, however, are almost universally displeasing and repulsive; consequently, such mills frequently are located in one-industry towns whose livelihood depend on success of the mills. While communities which are economically dependent on such a single industry are not likely to complain, people in neighboring jurisdictions, whose comfort, enjoyment and welfare are disturbed by the malodors, are not so tolerant or constrained.

Effects of odors on behavior have been given insufficient attention. It is known, however, that psysiological processes of any individual with respiratory ailments will be adversely affected, however slightly, by odors and other air pollutants. Thus, the condition of an afflicted person under the influence of odors will be exacerbated to the level of a person with a more advanced respiratory condition. This can result in loss of sleep, general weakness, greater susceptibility to other diseases, irritability, loss of appetite and loss of work days.

A healthy individual, while he may not be greatly affected by low-level chemical and particulate pollutants, undoubtedly will be affected by noxious odors. While odors may not cause organic disease, they can seriously affect his behavior adversely, on both physiological and psychological bases.

Offensive odors such as originate from the International Paper Company's pulp plant generally are recognized as capable of producing nausea, vomiting and headache; curbing appetites; disturbing sleep; upsetting stomachs; hampering proper physiologic breathing; offending the senses and interfering with comfortable enjoyment of property. They can mar good dispositions and provoke irritability.

Sociologically, such odors reduce personal and community pride, interfere with human relations in various ways, discourage capital investments, lower socio-economic status and damage a community's reputation. Economically, they can stifle growth and development of a community. Both industry and labor prefer to locate in an area which is a desirable place to live, work and play; and the natural tendency is to avoid areas with obvious odor problems. Tourists shun polluted areas. The resulting decline in market or rental property values, tax revenues, payrolls and sales can be disastrous to a community.

CONCLUSIONS

1. Prevailing winds and terrain configuration tend to channel winds from the Ticonderoga, New York, area toward the Shoreham, Vermont, area.

2. On an annual average, winds flow from Ticonderoga, New York, toward Vermont more than 40 percent of the time and generally from the southwest and south-southwest about 25 to 30 percent of the time

3. Wind speeds are low to moderate; the atmosphere generally is unstable during the day and stable at night. The frequency of calms is about 10 percent and of light winds (0-3 miles per hour) about 20 to 25 percent, these occurring most frequently at night. The frequency of stable conditions, which are conducive to intense odor problems, is greater during summer and fall than in other seasons.

4. In the Shoreham, Vermont-Ticonderoga, New York, area, the International Paper Company's pulp mill at Ticonderoga, New York, is the only source of odorous gases characteristic of kraft pulping operations.

5. There is interstate transport of kraft pulping process odors across the State boundary from New York to Vermont.

6. Hydrogen sulfide is the pollutant of primary significance in the interstate problem, and the principal emission point is the pulp mill's recovery stack.

7. These odors are of such quantity, frequency, and objectionability as to endanger health and welfare of persons in the Shoreham, Vermont, area and the pollution is therefore subject to abatement under provisions of Section 105, Title I of the Clean Air Act, Public Law 88-206, as amended by Public Law 89-272 (42 U.S.C. 1857-1857g).

8. Technology is adequate to control the escape of odors to the outdoor atmosphere from kraft pulping processes. This technology could be applied at International Paper Company pulp mill at Ticonderoga, New York, in such a manner that emissions would not endanger the health or welfare of persons in Vermont.

9. It is recognized that the International Paper Company has made efforts to control the emission of noxious odors from its pulp mill in Ticonderoga and that additional effort is planned. Accomplishments to date have been inadequate to control the problem.

RECOMMENDATIONS

Based on the above conclusions, the conference participant for the Department of Health, Education, and Welfare recommends:

1. That International Paper Company be required to abate the emission, release and discharge of offensive odors from its pulp mill at Ticonderoga, New York, in accordance with the following schedule:

   a. On or before June 1, 1966, the Company submit to the New York State Air Pollution Control Board for review and approval plans, specifications and reports regarding equipment to be provided and methods to be employed for controlling the odor release from the recovery furnace, the venturi evaporator and any other significant sources.

   b. On or before December 1, 1966, the Company submit to the New York State Air Pollution Control Board such evidence as the Board may require to demonstrate binding commitments for the purchase, construction and installation of necessary equipment and the initiation of all other actions necessary to execute the approved plans for control of offensive odors.

   c. On or before June 1, 1967, the Company have in operation all equipment and take all other measures necessary to control the emission of odors, in accordance with approved plans, and submit to the New York State Air Pollution Control Board a final report regarding construction, installation and effectiveness of equipment and other measures which have been taken to control malodorous emissions.

2. That the New York State Air Pollution Control Board and the Vermont State Department of Health consult with each other and exchange information regarding the adequacy of any plans, specifications and reports submitted by International Paper Company, in accordance with the above recommendations, to abate the emission of odors from its pulp plant.

3. That the New York State Air Pollution Control Board maintain such surveillance as is necessary to monitor progress of International Paper Company in complying with the above time schedule for abatement of its odorous emissions.

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4. That the Vermont State Department of Health, from the date of this conference, implement a procedure for continuous surveillance and compilation of records to provide documentation of interstate travel of odors from the pulp mill operated by International Paper Company.

5. That the International Paper Company, the New York State Air Pollution Control Board and the Vermont State Department of Health each transmit to the Department of Health, Education, and Welfare, on or before July 1, 1966, January 1, 1967, and July 1, 1967, semi-annual reports of progress, or lack of progress and the reasons therefor, in implementing the above recommendations.

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FIGURE 1

Conference Area

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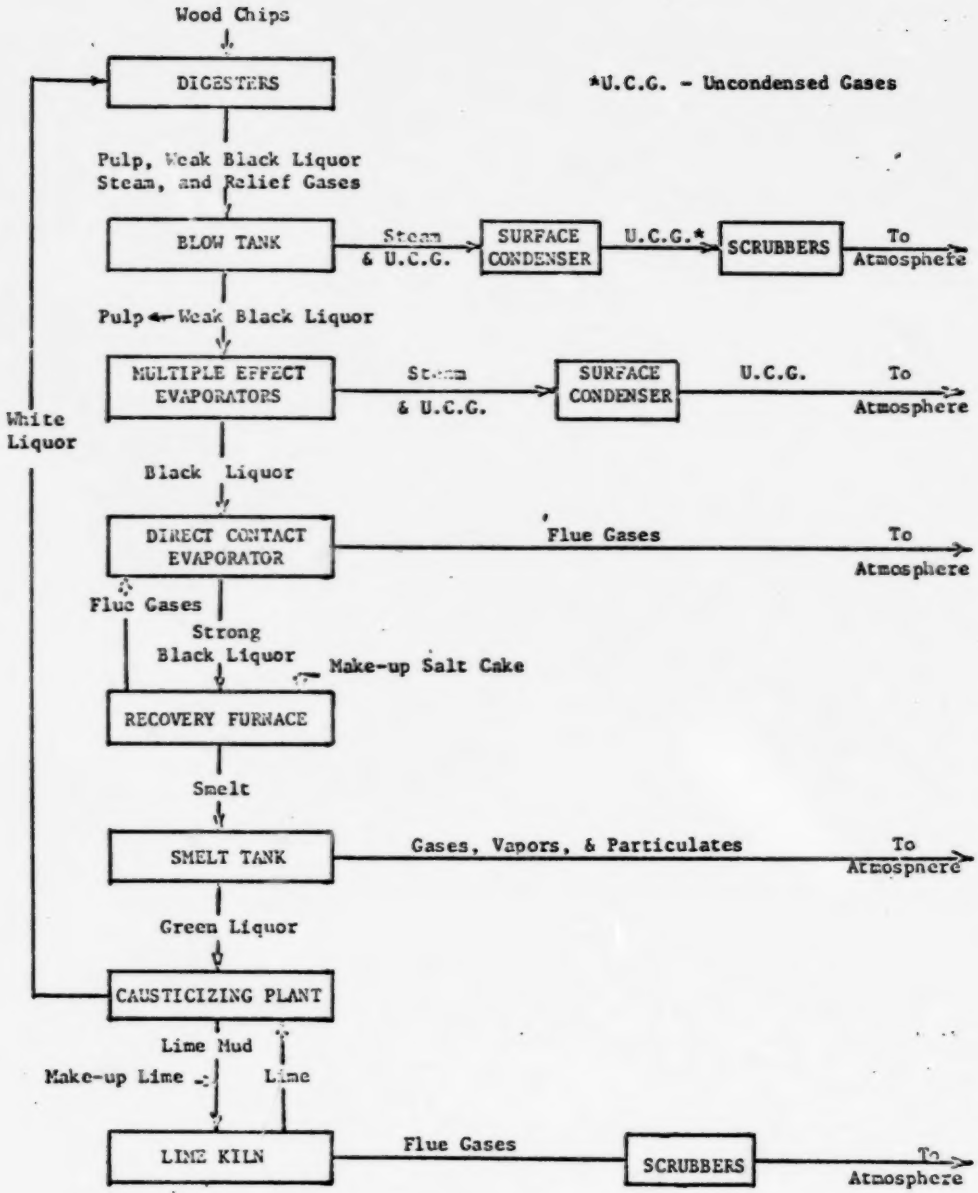

Figure 2. The Kraft Pulp Making Process

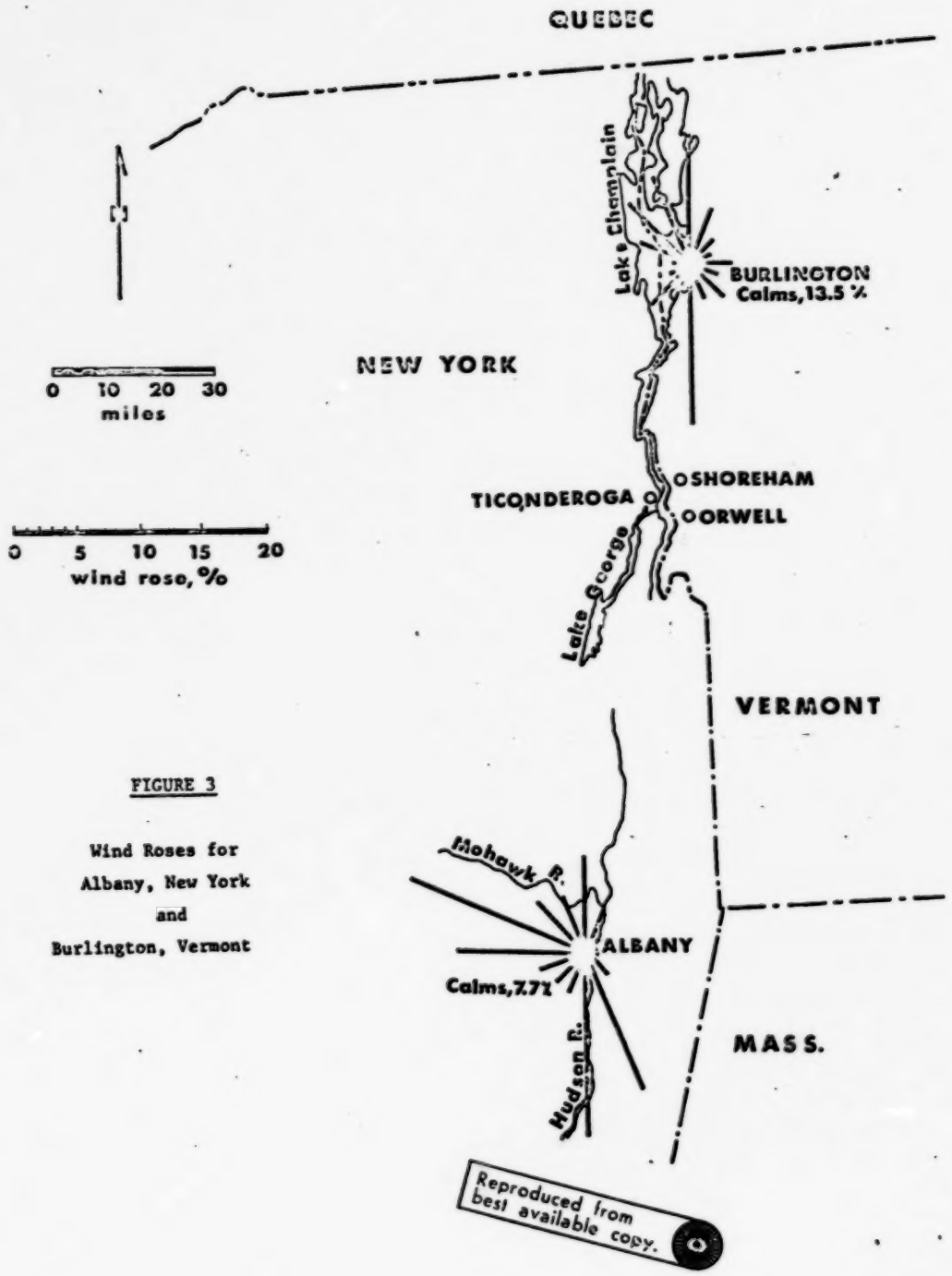

FIGURE 3

Wind Roses for
Albany, New York
and
Burlington, Vermont

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FIGURE 4

0.1 ppm H_2S 6.2 miles
Stable Conditions
Wind 2.5 m.p.h.

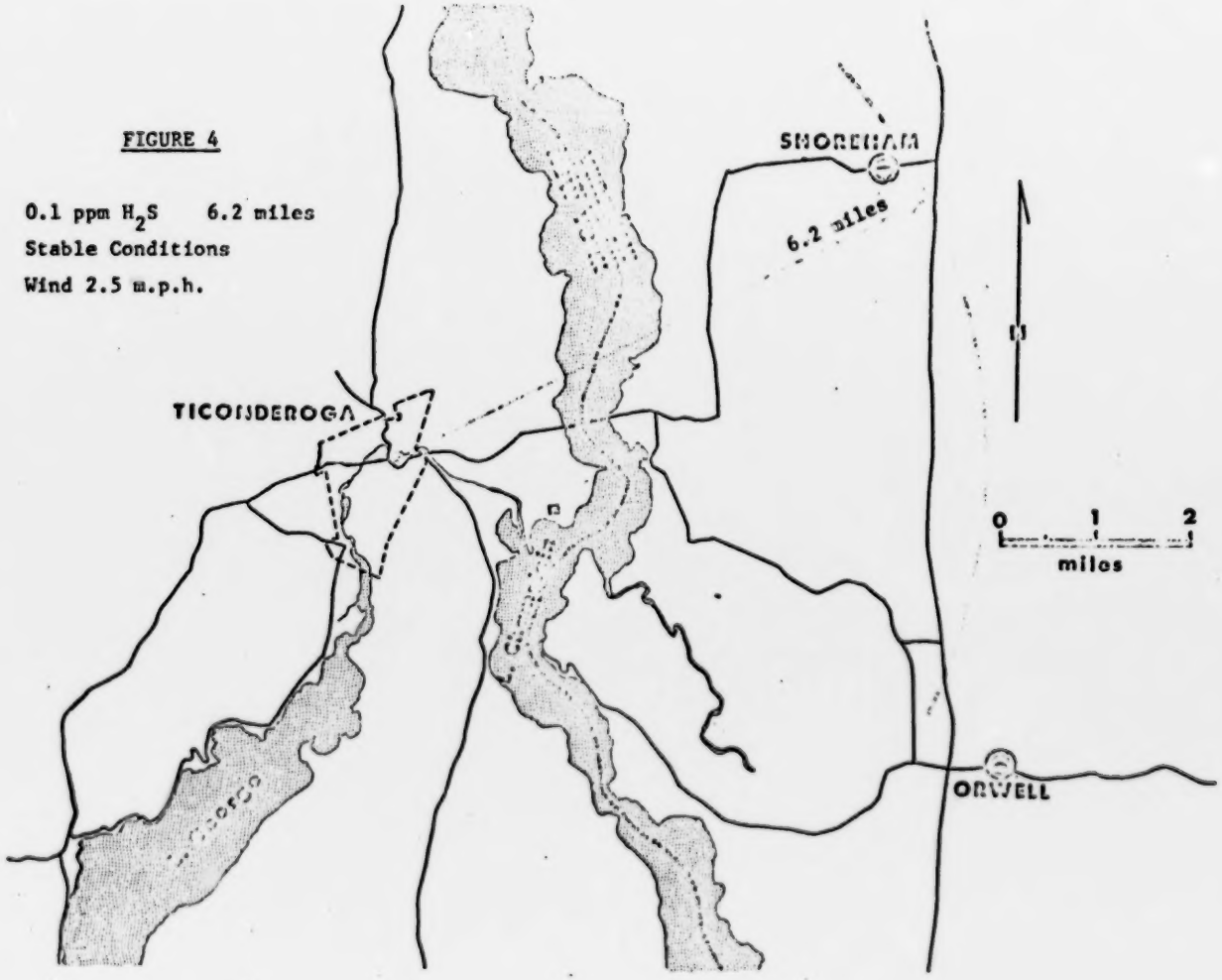

FIGURE 5

0.1 ppm H_2S 1.9 miles
10 ppb H_2S 33 miles
Stable Conditions
Wind 5 m.p.h.

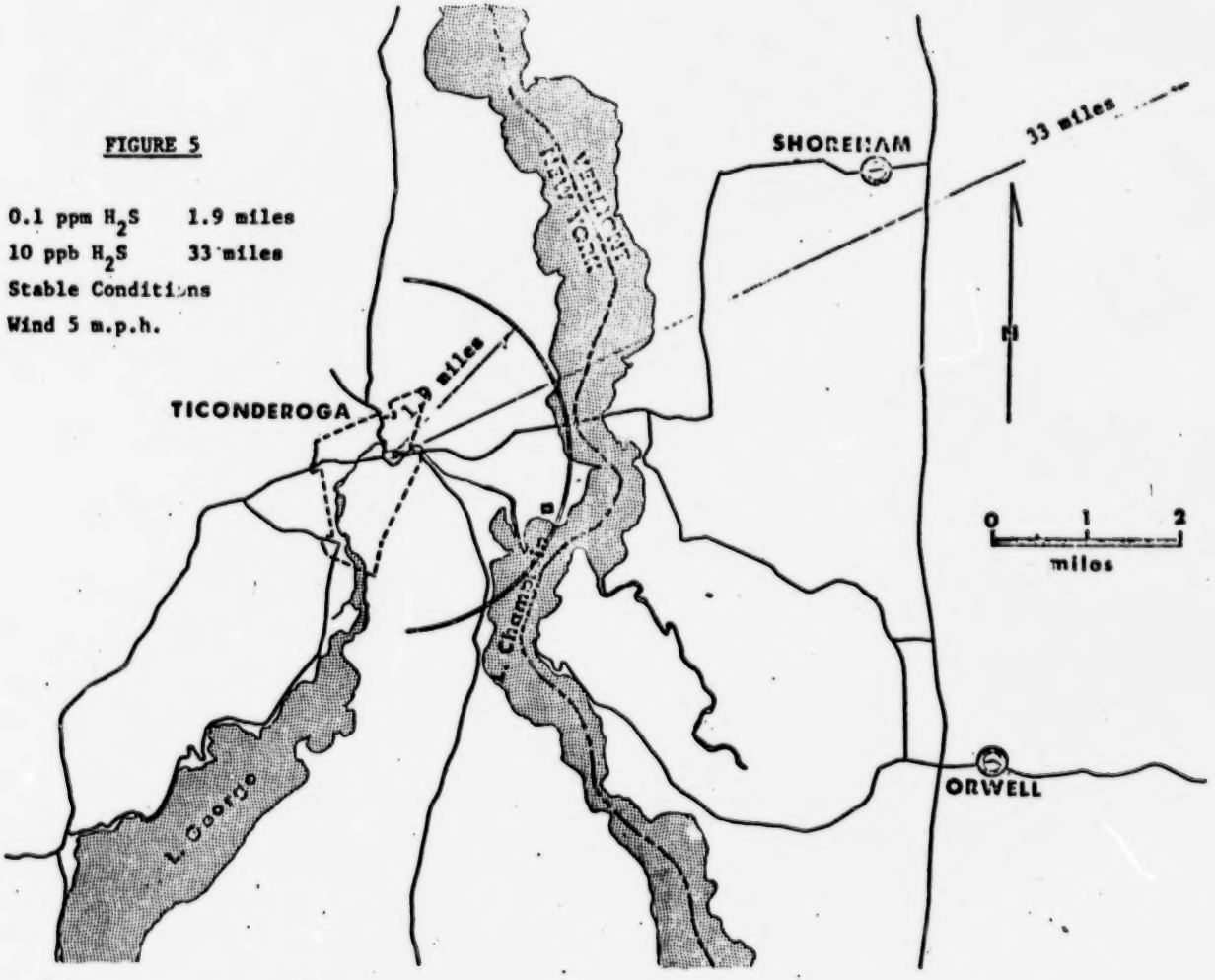

FIGURE 6

0.1 ppm H_2S 1.2 miles
10 ppb H_2S 7.5 miles
Neutral Conditions
Wind 5 m.p.h.

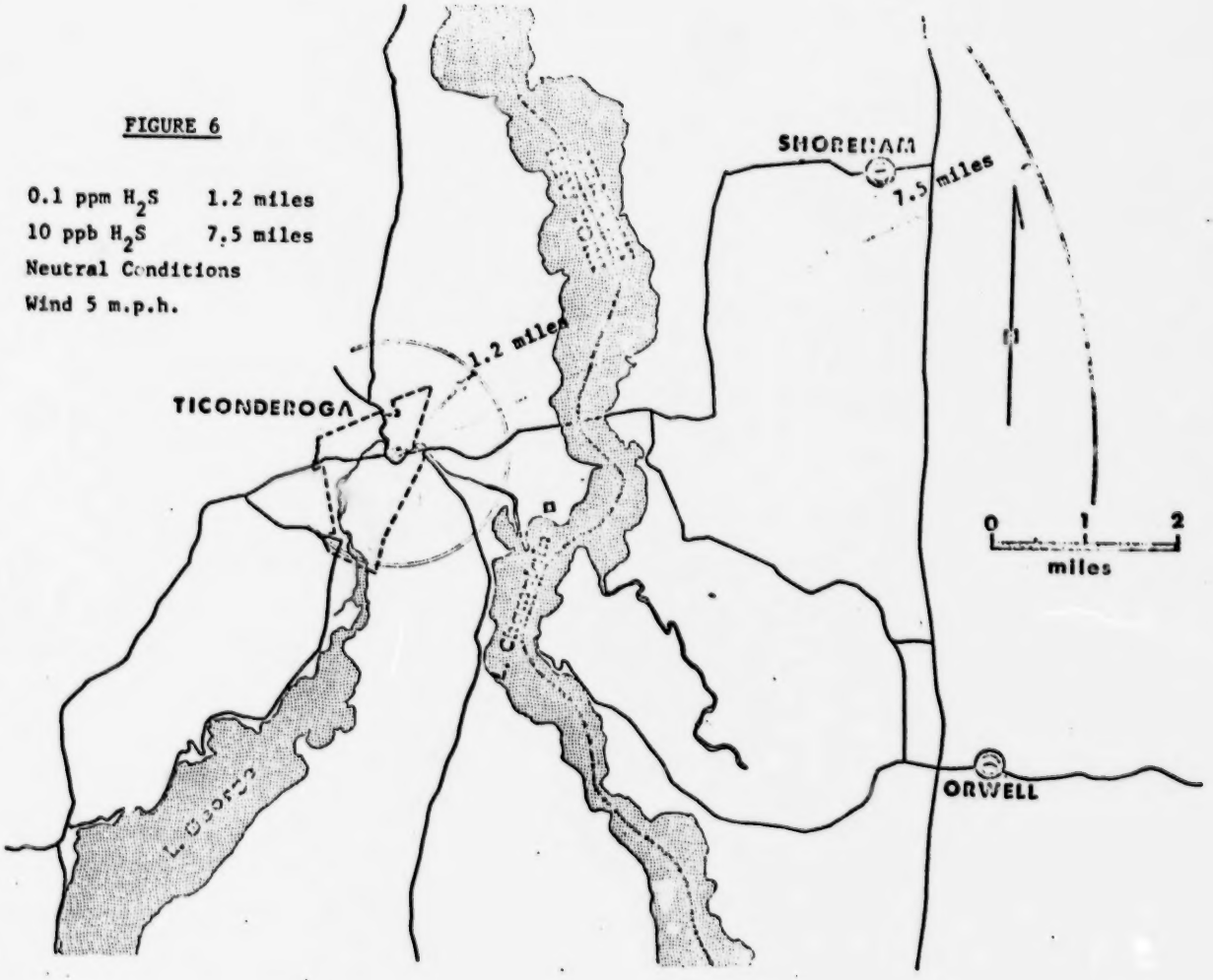

FIGURE 7

0.1 ppm H_2S 0.3 mile
10 ppb H_2S 0.5 mile
Unstable Conditions
Wind 5 m.p.h.

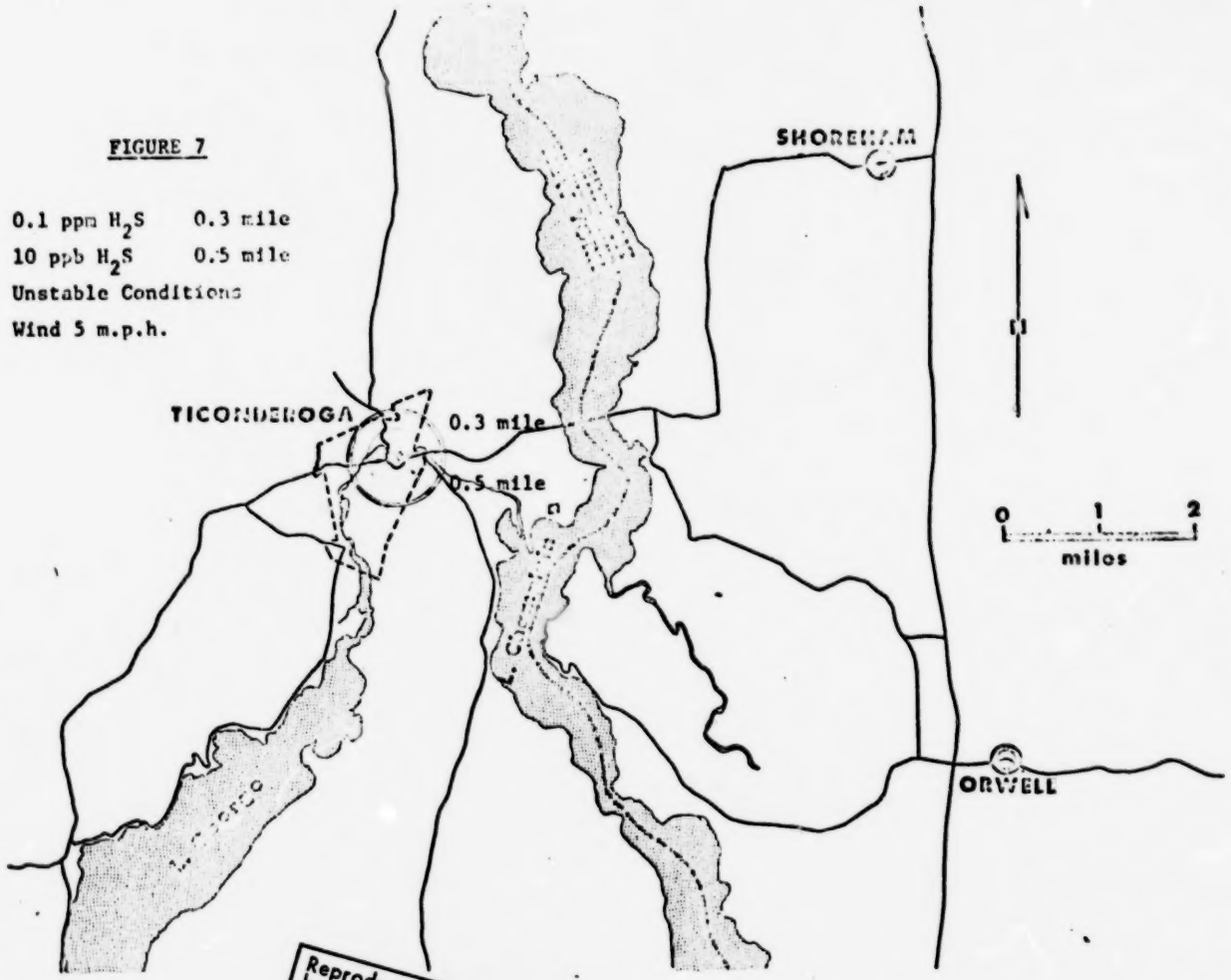

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FIGURE 8

0.1 ppm H_3CSH 2.2 miles
10 ppb H_3CSH 17.4 miles
Stable Conditions
Wind 2.5 m.p.h.

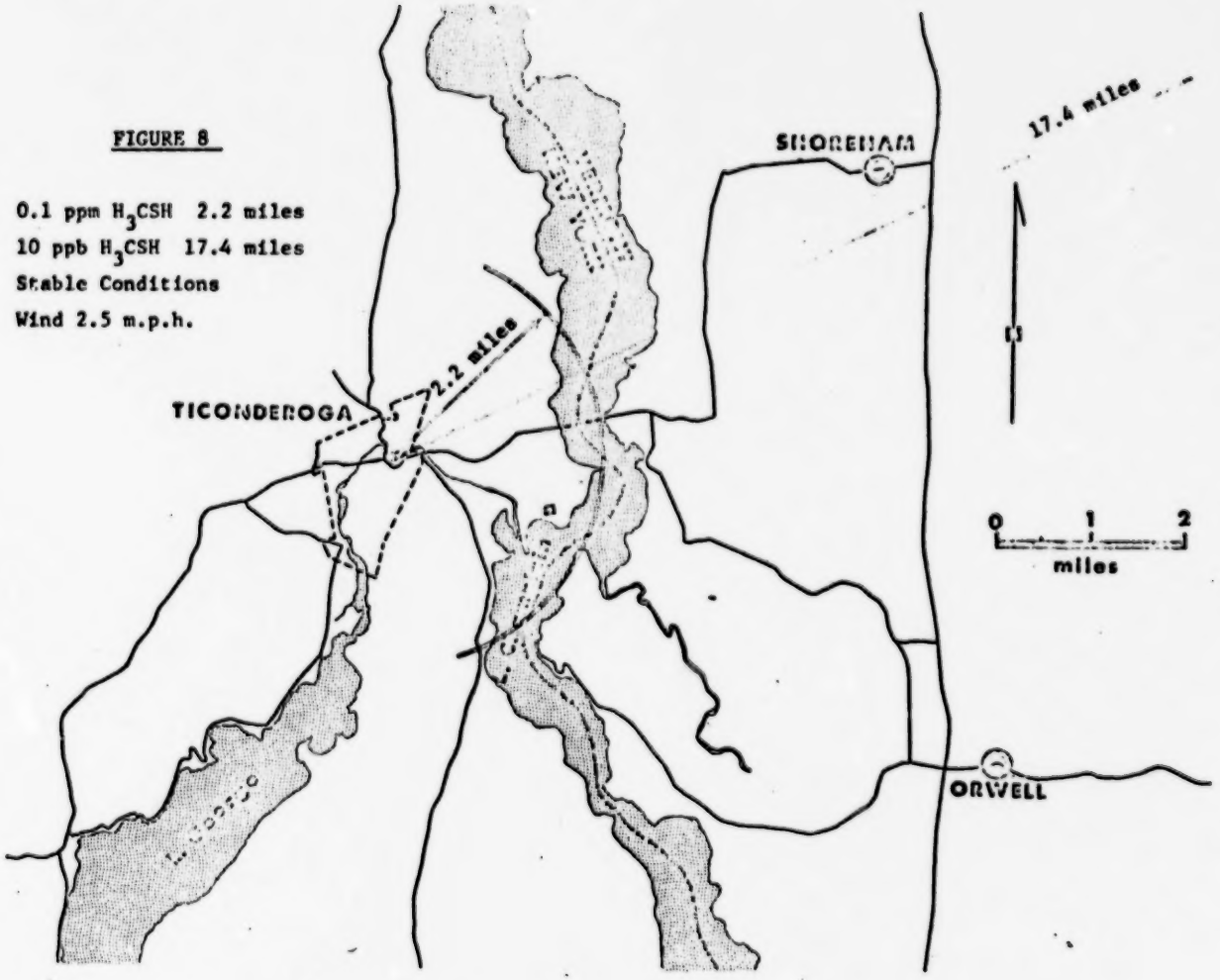

FIGURE 9

0.1 ppm H_3CSH 1.2 miles
10 ppb H_3CSH 9.3 miles
Stable Conditions
Wind 5 m.p.h.

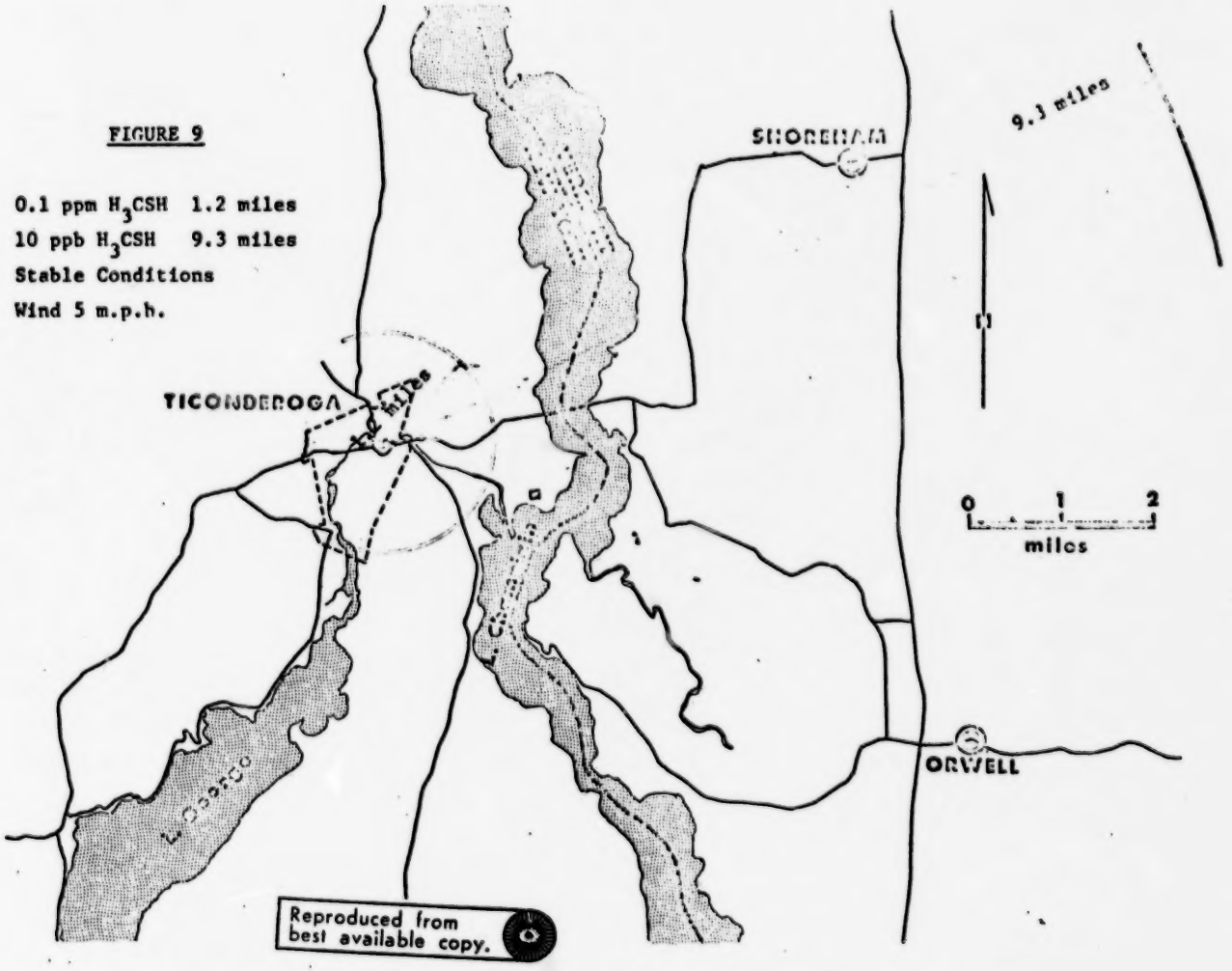

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FIGURE 10

10 ppb H_3CSH 2.5 miles
1 ppb H_3CSH 12.4 miles
Neutral Conditions
Wind 5 m.p.h.

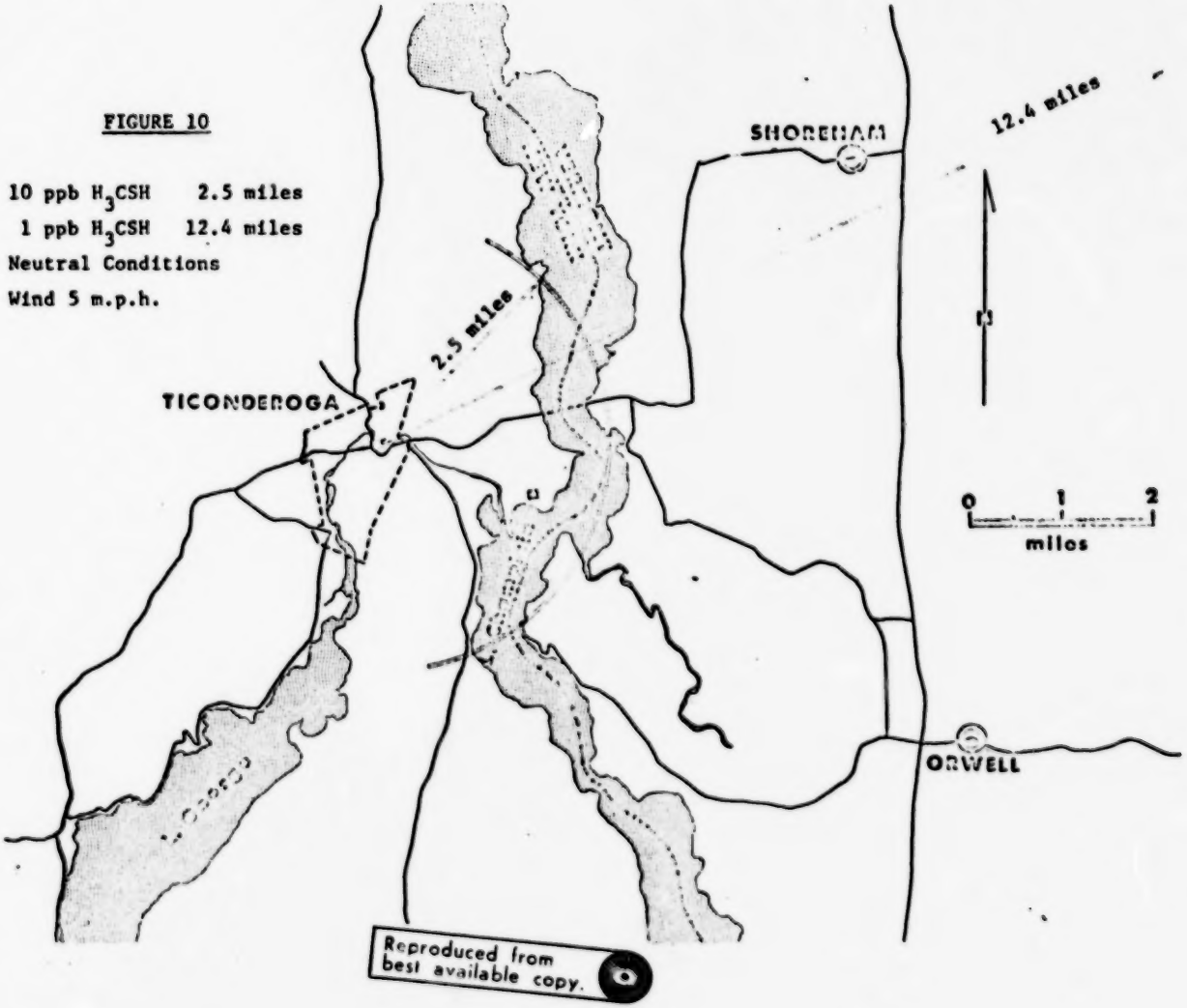

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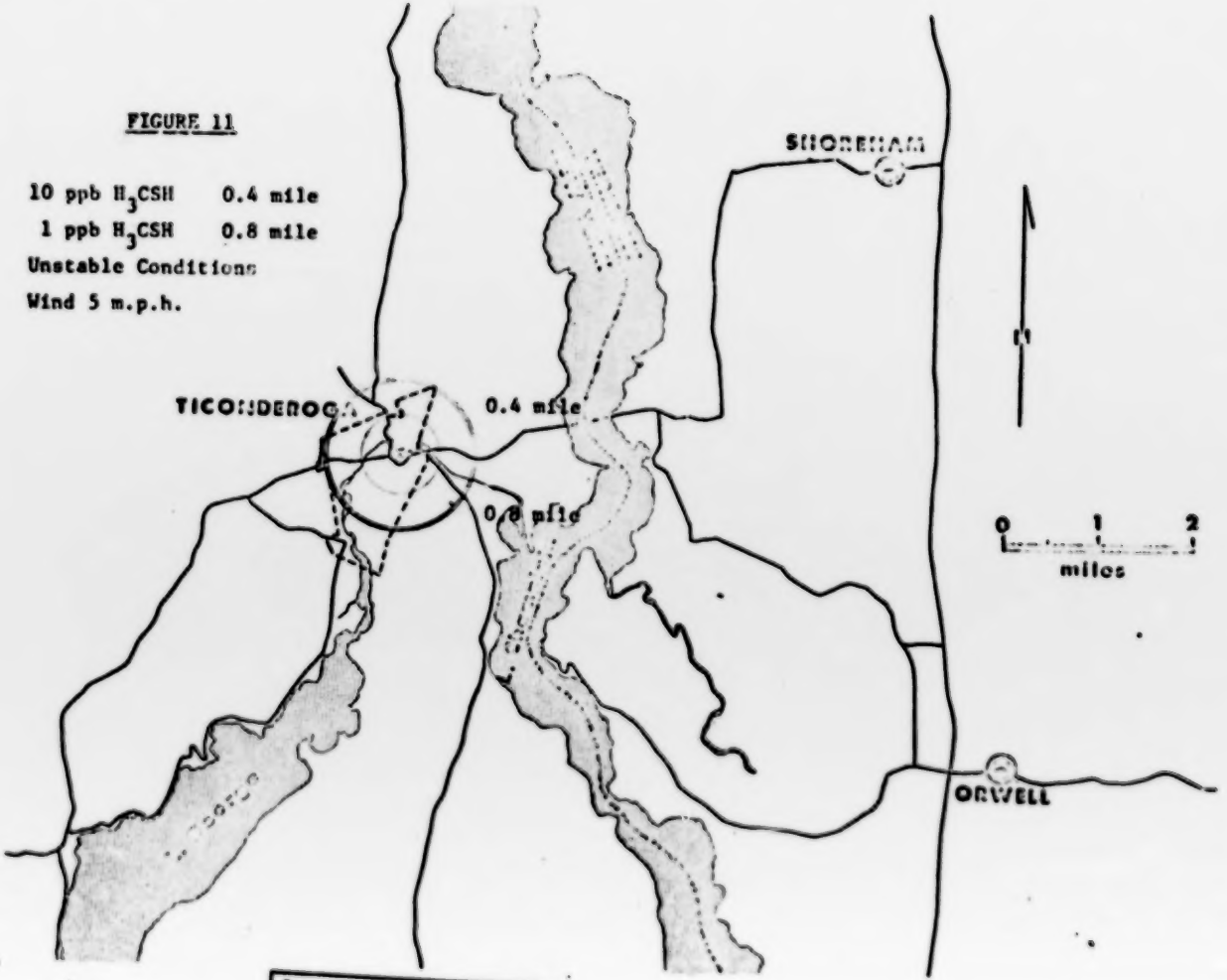
FIGURE 11

10 ppb H_3CSH 0.4 mile

1 ppb H_3CSH 0.8 mile

Unstable Conditions

Wind 5 m.p.h.



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